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THE EFFECT OF MAGNETIC THERAPY AND ACTIVE EXERCISE ON BONE MINERAL DENSITY IN ELDERLY WOMEN WITH OSTEOPOROSIS

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ABSTRACT

Purpose: To evaluate the effect of pulsed electro-magnetic therapy and exercise training on bone mineral density (BMD) in elderly women with osteoporosis. **Material and Methods:** A total of 30 elderly women with osteoporosis aged from 60 to 70 years old were randomly divided into two groups: A magnetic group consisting of 15 women who received pulsed electro-magnetic therapy at a frequency of 33 Hz and an intensity of 50 gauss for 50 min per session and an exercise group consisting of 15 women who practiced active exercises that included treadmill walking and selected exercises for hip and back muscles for 50 min per session. Both interventions were applied for three sessions/week for three months at a physical therapy clinic. Dual-energy X-ray absorptiometry was used to measure the BMD of the neck of the femur and the lumbar spine (L3-L5) before and after intervention. **Results:** Statistical analysis revealed that the BMD of the neck of the femur and the lumbar spine significantly increased in the two groups without a significant difference between them. **Conclusion:** Pulsed electro-magnetic therapy and exercises can increase BMD at the neck of the femur and the lumbar spine in elderly women. Physical therapists could apply pulsed electro-magnetic therapy or exercise training to increase BMD in elderly women.

Keywords: Osteoporosis; Pulsed magnetic field; Treadmill walking; Aerobic exercise.

INTRODUCTION

Osteoporosis is a serious and common condition in which bones become thin, brittle and easy to break, even with mild stresses such as bending over or forced coughing.[10] It is called a silent disease as it develops gradually and progresses without symptoms until the fracture occurs.[38] Fractures that result from osteoporosis are the major cause of morbidity in elderly individuals and place a huge financial burden on health services. Osteoporosis dramatically increases with advancing age.[22] Many risk factors have been found for osteoporosis, including menopause, prolonged cortisone therapy, low calcium intake, smoking, alcohol intake and lack of physical activity.[3]

Hormone replacement is the most widely prescribed pharmacotherapy used for the treatment of osteoporosis.[10,16] However, calcium, vitamin D, exercise training and smoking cessation are considered to be the primary preventive measures for osteoporosis and consequent fractures and adequate intake of calcium and vitamin D should be emphasized as cornerstones for the prevention and effective treatment of osteoporosis.[10,13,14,16,17]

There is an agreement in the literature that physical activities improve muscle mass and strengthen the bone.[2,5,23,37] Active exercises have significant osteogenic effects on bone structure, even during youth and periods of skeletal growth, and they can, for example, reduce fracture risk in later decades.[6,18,39] Active exercises serve to encourage calcium absorption in bone as a result of increased blood flow, which aids the deposition of vital nutrients and minerals such as calcium from general circulation in compressed sites.[6,17,21] Weight-bearing bones are maximally affected by gravitational forces and repetitive muscular actions during weight-bearing exercises, e.g. running and walking.[29] It has been reported that the bone mass of physically active individuals is significantly higher than their nonactive counterparts and that muscular contraction during strengthening exercises and gravitational forces create piezoelectric forces that affect bone remodeling.[23,31,37]

Accordingly, active exercises are one of the most important methods to prevent bone loss and to help maintain bone mineral density (BMD).[23,31] In addition they enhance aerobic capacity as well as increase muscle strength and flexibility, and improve posture and balance performance.[2,4,21] The positive associations between exercise and bone mass means that it is recommendable that people engage in active exercise programs to reduce the incidence of osteoporotic fractures and the rate of morbidity and/or mortality.[2,39] Brisk walking is suggested to be an ideal and simple form of active exercise, especially for osteoporotic postmenopausal women. Treadmill exercises, a useful form of walking and weight-bearing exercises, are low impact aerobic workouts and are suitable for the majority of elderly patients.[12,39]

Recently the application of magnetic therapy during physical therapy has shown promise in the treatment of different disorders, e.g. osteoarthritis, and other conditions via, for example, healing bone and ulcers and relieving pain.[9,20,28,35] A magnetic field always exists when there is an electrical current flow and it can penetrate through highly resistant structures such as bone.[9] Exposure to pulsed electro-magnetic fields (PEMFs) increases BMD in animals and humans who are prone to osteoporosis.[11,28] Li-qun *et al*.[25] concluded that low-frequency PEMFs may increase BMD and enhance bone cell formation in secondary osteoporosis.[25]

In a recent systematic review and meta-analysis, it was postulated that there is still a need for further well-designed randomized controlled trials to quantify the effect of exercise on bone strength and its structural determinants.[31] At the same time magnetic therapy has become a therapeutic modality due to its positive osteoblastic effects. Furthermore, a large number of the elderly cannot practice exercises as a result of associated advanced complications and bed recumbence, increasing the potential usefulness of magnetic therapy.

Based on the related literature the aim of this study was to evaluate the effect of active exercises on BMD and to determine if magnetic therapy can be considered an alternative therapeutic modality to improve BMD and retard osteoporosis progression.

METHODOLOGY

Study approval

The approval of this study was given by the institutional review board before starting patient assessment and treatment.

Subjects

A total of 30 elderly women participated in this study. Their ages ranged from 60 to 70 years old. They were randomly selected from elderly nursing homes in Cairo with the following inclusion criteria: A T-score of ≤ -2.5, with oral calcium supplementation (1000 mg/day), alendronate sodium (one 70 mg tablet/week) and vitamin D (400 IU/day) and a Berge balance scale score of at least 41 was used to select patients with a sufficient balance performance (low fall risk) to enable them to perform the exercises.[27,30] Subjects were excluded from the study if they had advanced musculoskeletal problems, unstable cardiopulmonary conditions, or were receiving hormone replacement therapy or any medications that interfere with balance. All participants were informed that collected data would be submitted for publication and they signed an informed consent form before their participation.

Instrumentation

(A) Evaluative Instrumentation: Dual-energy X-ray absorptiometry (DEXA; GE Medical Systems, USA), a bone densitometer, was used to measure the BMD at the neck of the femur and the lumbar spine (L3-L5) in each patient of the two groups before and after the treatment programs.

(B) Therapeutic Instrumentation:

(1) ASA magnetic field (Automatic PMT Quattro PRO.), which consists of an appliance, motorized bed and solenoids. It is provided with 1 couch with a 80 cm diameter manually sliding solenoid and two FLEXA applicators with vibrating effect. The appliance is capable of generating PEMFs with a pulse repetition frequency up to 100 Hz and an intensity of 85 gauss.

(2) Electronic treadmill (En Tred with a computerized speed detector and heart rate monitor to determine pulse rate during walking exercises and support bars for safety. It is with 1.0 to 4.0 HP AC Motorized Treadmill with Taiwan Alatech Controller, HRC, Healing, MP3 and USB Function. Zhejiang Outdo Fitness Manufacturing Co. Ltd
(3) Wall bars were used to perform specific exercise training from a standing position.

Assessment procedure

DEXA was used to measure the BMD of the neck of the femur and the lumbar spine (L3-L5) for every patient before and after the treatment programs.[1,26]

Treatment procedure

Magnetic group: A total of 15 patients received low frequency and low-intensity pulsed magnetic therapy. The magnetic device was applied to each patient from a comfortable supine lying position. After connection of the appliance to a power supply, the solenoid was adjusted over the affected parts of the body (lumbar spine and hip regions). Magnetic therapy was applied with a frequency of 33 Hz and intensity of 50 gauss for 50 min in each session, three times per week for three months.[11,25]

Exercise group: A total of 15 patients practiced the exercise training program (treadmill and aerobic exercises) for 50 min, three times per week for three months. This program consisted of a walking exercise on the treadmill (20 min) in addition to selected aerobic exercises for hip and lumbar muscles (25 min) with a rest period (5 min) between the treadmill and aerobic exercises.[4,23,38]

(A) Walking exercise: Each patient was asked to walk with normal breathing for 20 min on the treadmill at zero inclination, three times per week for three months. The treadmill was stopped if there was any symptom that limited the exercise such as fatigue, balance disturbance, excessive sweating, breathlessness, chest pain or leg cramps. Walking exercise included:
   (i) Warm up phase: Each patient was asked to walk for 5 min on the treadmill at the lowest speed.
   (ii) Stimulus Phase: Each patient was asked to walk for 10 min on the treadmill at a greater intensity (from 40% to 60% of the pre-determined individualized maximal heart rate) or according to patient tolerance. The intensity was increased only by increasing the speed of the treadmill in a horizontal position.
   (iii) Cool down phase: Each patient was asked to walk for 5 min on the treadmill at the lowest speed.

(B) Hip and lumbar muscle exercises[40]: Each patient practiced these exercises for 25 min every session, three times per week for three months. A sustained 5 s muscle contraction for each exercise was followed by 10 s of relaxation. Each exercise was repeated 10 times for both the lower limbs and back and each patient took 30 s rests between each type of exercise.
   (i) Hip extensor exercise from a comfortable standing position: Each patient stood facing the wall bars with one foot distance between both her feet, firmly grasped the wall bars at chest level, extended the right lower limb backward as far as possible and maintained this position for a few seconds before relaxing. Each patient did the same exercise for the left hip.
   (ii) Hip abductor exercise from a comfortable standing position: Each patient was

asked to abduct her right lower limb sideways as much as possible and to maintain this position for a few seconds, before returned to the starting position and relaxing. Each patient did the same exercise for the left hip.

(iii) Hip abductor exercise from a comfortable left side lying position with flexed left knee: Each patient was asked to raise up her right lower limb, held straight, as high as she could and to maintain this position for a few seconds before returning to the starting position. Each patient did the same exercise for the left hip from the right side lying position.

(iv) Back exercise from crook lying position: With both feet rested on a plinth, each patient was asked to raise her waist as high as she could to make a bridge and to maintain this position for a few seconds before returning to the starting position and relaxing.

(v) Back exercise from sitting position: From a sitting position on a comfortable chair with a pillow behind her back, each patient was asked to push backward against the pillow and to maintain this position for a few seconds before returning to the starting position and relaxing.

STATISTICAL ANALYSIS

The collected data were analyzed using SPSS (Version 16.0). A paired *t*-test was used to compare the mean T-score values of the neck of the femur and the lumbar spine before and after intervention within each group. An independent *t*-test was used to compare the mean T-score values of the neck of the femur and the lumbar spine before (pre-test) and after treatment (post-test) between both groups. Statistical significance was determined at a p-value < 0.05 and confidence interval of 0.95.

RESULTS

A paired *t*-test was used to determine the significance of changes in the T-score, which represents the BMD, of the neck of the femur and the lumbar spine before and after intervention in both the magnetic therapy and exercise training groups. Analysis showed a significant increase in the T-score after exposure to both magnetic therapy ($p < 0.05$; Table 1) and the exercise training program ($p < 0.05$; Table 2).

However, comparison between the two groups using an independent *t*-test showed that there were non significant differences ($p > 0.05$) between the T-score of the neck of the femur (Table 3) and the lumbar spine (Table 4) of the magnetic and exercise groups before and after intervention.

Table 1 The Mean Values of the T-Score Pre and Post Treatment in Magnetic Group.

Variables	Neck of Femur		Lumbar Spine	
	Pre	Post	Pre	Post
Mean	−2.78	−2.3	−2.83	−2.47
SD	0.67	0.5	0.48	0.39
T-value	3.67		4.23	
p-value	0.002*		0.00*	

Table 2 The Mean Values of the T-Score Pre and Post Treatment of the Exercise Group.

Variables	Neck of Femur		Lumbar Spine	
	Pre	Post	Pre	Post
Mean	−2.74	−2.31	−2.69	−2.44
SD	0.46	0.47	0.57	0.33
T-value	5.67		2.63	
p-value	0.00*		0.01*	

Table 3 The Mean Values of the T-Score at the Neck of Femur Pre and Post Treatment in Both Groups.

Variables	Group A Pre	Group B Pre	Group A Post	Group B Post
Mean	−2.78	−2.74	−2.3	−2.31
SD	0.67	0.46	0.5	0.47
T-value	0.22		0.18	
p-value	0.83†		0.86†	

Table 4 The Mean Values of the T-Score at Lumbar Spine of Both Groups.

Variables	Group A Pre	Group B Pre	Group A Post	Group B Post
Mean	−2.83	−2.69	−2.47	−2.44
SD	0.48	0.57	0.39	0.33
T-value	0.83		0.3	
p-value	0.41†		0.76†	

DISCUSSION

In the current study, BMD was evaluated by DEXA with the finding that the mean T-score values of the neck of the femur and the lumbar spine (L3-L5) of elderly women significantly increased after magnetic therapy. These results are supported by previous experimental studies performed in rats, where it was found that electromagnetic fields of low intensity and frequency significantly suppresses trabecular bone loss and restores trabecular bone structure in bilateral ovariectomized rats and that PEMF stimulation for eight weeks enhances BMD in rats with disuse osteoporosis.[7,34]

The improvements in bone metabolism due to magnetic therapy can be explained by a number of mechanisms. It stimulates osteogenesis by simultaneously increasing osteoblastic activity and decreasing osteoclast formation, thereby shifting the metabolic process towards bone osteogenesis.[7,15,28,37] It also enhances fibrocartilage turnover to bone cells and increasing ionic calcium channels.[28] In addition, it increases blood supply at the site of application, which is considered to improve bone healing.[25] Furthermore it has an inhibitory effect on the resorption phase of wound healing that leads to early callus formation.[35] Many authors consider magnetic therapy to be of an interesting physical modality because it has many advantages. For example, it is a noninvasive, easy, safe and focused method of treatment for the concerned site in the body.[15,25] It also can save many elderly people from undergoing surgery and it is being suggested that magnetic therapy be the first line of treatment for osteoporosis.[11]

However, in contrast to our results, some authors found that treatment with magnetic therapy did not cause a significant increase in BMD.[15] The variability in these results may be due to a number of differences between the two studies: First, the mean age of their sample was more advanced (> 75 years old) than in the current study (60 to 70 years old). Secondly, magnetic therapy in their study was not used in conjunction with sufficient calcium and vitamin D supplementation, while in our study all patients received one alendronate tablet of 70 mg/week, oral calcium (1000 mg/day) and vitamin D (400 IU/day) during the entire treatment period. Thirdly, there was a difference between the magnetic therapy parameters that was 100 Hz vs 33 Hz in this study).[15] Many other studies have shown that BMD is higher after 3−4 months of magnetic therapy[11,25] and the benefits of three months of PEMFs were previously proved in a randomized controlled trial.[19] It has been suggested recently that standardization of frequency, intensity and session time of magnetic therapy is required, as parameter differences are considered to be one of the limitations of magnetic therapy.[11]

The second finding is that the BMD of the neck of the femur and the lumbar spine of the elderly women was also improved by an exercise program. This improvement has also been shown previously.[12,37] A program of weight-bearing training and aerobic and balance exercises undergone by elderly women for 12 months improved bone density as well as muscle strength and walking ability.[12] Another study found that elderly women who exercise regularly have 30% denser bones than similar individuals who do not exercise.[37]

Many explanations for the benefits of weight-bearing exercises can be found in the literature. For example, the mechanical loads of weight-bearing activities are transmitted to the skeleton by muscle pull and gravitational forces where the bone cells selectively respond to different mechanical stresses to increase or decrease BMD.[31,32] In addition the bone tissue responds to dynamic, rather than static, loading as dynamic loading creates fluid movement in the bone network, which in turn generates shear stresses on the plasma membranes of osteocytes and osteoblasts.[39] There is agreement in the literature that exercises not only improve BMD but also increase muscle strength, flexibility, postural stability, balance and reduces risk of falling.[5,21,32,40]

Resistance training and weight-bearing aerobic exercises are recommended for osteoporosis treatment by some investigators.[32,40] These exercises are the main components of our exercise program. Treadmill walking was used in the current study because it is the best known way to prevent bone loss in the elderly.[38] Walking adds the stress required to the hip joint and lumbar spine to build bone density in a natural way and thus increases BMD in lumbar vertebrae and the neck of femurs.[24,38] In addition the specific strengthening exercises can retard and even reverse bone loss in healthy postmenopausal women.[33] Therefore, in the current study active exercises of hip and back were used to obtain maximum benefits.[12,39]

The exercise program in our study was applied three times per week and maintained for 50 min to influence BMD, a training regime whose efficacy is supported by the literature.[32,38] While there is controversy regarding the total duration of the exercise program in the literature, some authors recommend 12 months of training.[12,38] Others practiced eight months of specific exercise on postmenopausal women to increase the BMD of the lumbar spine,[15] while in another study a combined aerobic and anaerobic exercise regime was applied in overweight postmenopausal women for 12 weeks.[36] Furthermore, in more recent studies, Chang *et al*.[8] applied treadmill exercise for 36 weeks on ovariectomized rats[8] and Westcott *et al*.[40] applied strength and aerobic workouts for 36 weeks on subjects that ranged in age from 39 to 82 years. Consequently we selected three months (12 weeks), as previously used,[36] because intervention in the present study included, for one group, magnetic therapy, for which three months has previously been shown to be an efficient duration of exposure.[11,20,25]

The third finding of the current study is that no significant difference was found in the BMD of the neck of the femur or the lumbar spine between the magnetic and exercise groups. As far as we know, no clinical study has compared these two types of intervention. Consequently it is recommended that more clinical studies with larger sample sizes and longer treatment periods are conducted in order to better compare both interventions.

CONCLUSION

Either magnetic therapy or an exercise program can increase BMD in elderly osteoporotic women. Magnetic therapy could be used for the treatment of osteoporosis in elderly women who cannot undergo exercise training as a result of common associated chronic complications of the elderly.

Limitations of this study

(1) A small number of patients were included in the study (only 30 female elderly subjects in total).

(2) The period of observation for both treatment groups was three months, which may be short to quantify significant changes between both treatment in T-score. So it would be preferable to do follow-up at longer times for the involved subjects.

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